US Geological Survey - Woods Hole Science Center

North Carolina Regional Coastal Erosion Studies

SUMMARY:

This project is mapping the regional coastal sedimentary system of northern North Carolina in order to understand the Quaternary evolution of the coastal system, especially coastal erosion. The study area includes the Cape Hatteras National Seashore, Cape Lookout National Seashore, the Wright Brothers National Memorial, and Pea Island National Wildlife Refuge. Coastal erosion along the Outer Banks of North Carolina has received much engineering, scientific, and political attention during the past 30 years. This interest is because the study area attracts significant tourism to its parks and beaches, contains a number of coastal communities, and the coastal ocean supports a local fishing industry; all of which are impacted by coastal change. Among the most important issues to be addressed by the products and knowledge developed from this project are: coastal and estuarine shoreline erosion (controls on erosion rates, sediment transport, response of beaches and wetlands to sea level rise); sand resources (location, quality, and quantity of offshore, estuarine, or onshore sand); storm impacts (barrier island/inlet migration, estuarine water movement, relative stability of barrier island segments); sea-level change (history and potential impacts); water resources (surface and groundwater); habitat (ability to sustain uses, trends, identify threats). The project is providing a strong science foundation for management of the North Carolina coastal zone.

NC erosion image

INVESTIGATORS:

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DESCRIPTION:

This multidisciplinary project seeks to understand the regional geologic framework and the physical processes driving the evolution of the northeastern North Carolina coastal system. The long-term project goal is to acquire comprehensive knowledge of this coastal system, including the estuaries, barrier islands, and inner continental shelf. This knowledge will be used to understand the linkage of geologic framework and physical processes to coastal evolution and possibly predict the coastal response to oceanographic and climatic forcing at time scales from storm events to centuries. Many of the research tasks are focused on, or can be used to identify and quantify, coastal hazards. Shoreline change (SWASH) monitoring provides information on the spatial and temporal response of the ocean shoreline to storm events, and provides insight into erosion hazard areas along the immediate shoreline. Nearshore geophysical surveys have linked erosion hotspots to specific surf zone morphologies that may recur over time due to interactions between physical processes and the shallow geologic framework. Ground-penetrating radar studies can identify pre-historic and historic inlet locations that may be reoccupied in future storms. Geomorphic mapping using historical air photos and recent LIDAR data shows the evolution of landform types, the impact of humans on the landscape, and resulting changes in coastal vulnerability to storms and long-term shoreline change. Geophysical surveys of the inner continental shelf provide an understanding of the geologic history of the coastal system, furnish insight into coastal sediment flux, and identify sand resources for mitigating erosion hazards through beach nourishment. Regional geologic mapping shows that the underlying geologic framework of Quaternary sediments determines the availability and distribution of sediment in this coastal system and controls the overall barrier island geomorphology. For example, sediment-rich coastal segments have high, wide, accretionary barrier islands dominated by beach ridges, while sediment-starved coastal segments have narrow, washover-dominated barrier islands. Recognizing coastal hazards as a function of geologic setting and physical processes allows sound planning of hazard mitigation strategies.

START DATE OF PROJECT:

October 1, 2002

END DATE OF PROJECT:

September 30, 2007

LOCATION:

North Carolina

TOPIC:

Coastal Erosion Assessements and Loss Reduction Products, Secondary Earth Surface Dynamics, Monitoring, Modeling and Forecasting

APPROACH:

This project is using a systematic, phased approach to studying this coastal system involving three basic components that follow in sequence: 1) a geophysical/geologic mapping phase, 2) a process-based, field measurement or observation phase, and 3) a model development or predictive phase. The latter includes the development of conceptual as well as analytical or numerical models. The northeastern North Carolina coastal system contains an exceptionally thick and well preserved Quaternary stratigraphic record. The major goal is to map this Quaternary section on the inner continental shelf, Outer Banks barrier islands, Albemarle#Pamlico estuarine system, and adjacent land areas to define the geologic framework, develop a detailed evolutionary history, and understand the ongoing process dynamics driving this large, complex, and rapidly changing, high-energy coastal system. Preliminary synthesis of data from the geologic mapping phase of the project demonstrates that the major controls dictating the present health and future evolution of this coastal system includes the following factors. 1) The regional morphology of late Pleistocene stratigraphic units constitutes the underlying geologic framework that the Holocene (modern)coastal system has inherited. 2) The controlling paleotopography is a series of lowstand drainage basins consisting of trunk and tributary streams and associated interstream divides that are being drowned. 3) Three major sediment sources dictate the highly variable sand resources available to specific barrier segments and include riverine channel and deltaic deposits associated with lowstand trunk streams, the large cross-shelf cape shoal sand deposits, and sand-rich units occurring within the adjacent shoreface and inner shelf strata. 4) Wherever large sand supplies have historically been available, the barrier segments occur as complex islands with large sand volumes producing high and wide barriers, whereas barrier segments without adequate sand supplies are sediment starved and occur as simple overwash barriers. 5) Human modification of the barrier islands over the past seven decades represents a major force that has significantly changed barrier island dynamics and evolution. 6) The Albemarle Embayment (i.e., northeastern North Carolina) appears to have a slightly higher rate of sea-level rise than adjacent regions due to regional subsidence. Consequently, if the ongoing pattern of storm activity and sea-level rise either continues or increases during the next few decades to centuries, specific simple overwash barrier segments on the Outer Banks that are currently disintegrating, will ultimately collapse into Pamlico Sound. These barrier segments will back-step across the open marine Pamlico Embayment and reform on the mainland side. A few sand-rich complex barrier segments will persist as isolated, but perched and eroding islands for some longer period of time. In contrast, simple overwash barrier segments that have received minimal human modification and are associated with narrow and shallow back-barrier sounds, appear to be maintaining themselves in their upward and landward migration in response to ongoing storms and sea-level rise.

IMPACT/RESULTS:

This work addresses a variety of issues, including coastal erosion hazards and refining our understanding of a coastal sediment budget. Although a sediment budget is an important design element in the development of erosion mitigation strategies, such budgets are rarely accurate because necessary temporal and spatial data are sparse. Adding to the difficulty of formulating an accurate sediment budget is the realization that coasts with limited sand supplies, such as much of the Atlantic margin of the U.S., are significantly influenced by the geologic framework of older stratigraphic units that occur beneath and seaward of the littoral zone. Working within this difficult context, a better understanding of sediment dynamics in coastal areas can be attained by mapping the surface sediment distribution and subsurface stratigraphy of the estuaries, beach, shoreface, inner shelf, and subaerial components of the coastal system. Presently, our findings are being used by the Corps of Engineers (USACE) to refine sand resource exploration strategy, by the National Park Service (NPS) to reassess the impact of proposed coastal mitigation strategy, and by the Fish and Wildlife Service (FWS) to evaluate the environmental consequences of inlet abandonment. We are having a similar impact with state agencies, county and local managers, and other stakeholders as well. Endorsements, support, and cooperation have come from the North Carolina Coastal Resources Commission (CRC), several state and federal resource agencies, and local governments, who all have an interest in the information the project is producing. Supplemental Congressional appropriations have resulted in part from such support. The National Park Service has also provided partnership funding. Additional partnership opportunities exist and are being pursued with the USACE (two large-scale nourishment project feasibility studies are active in the project area), the North Carolina Outer Banks Task Force and Department of Transportation, and U.S. Minerals Management Service. The Project Chief (Thieler) and primary collaborators (Bill Hoffman - NCGS and Stan Riggs - ECU) meet regularly with state and local officials. We have appeared individually and as a group before the state Coastal Resources Commission to deliver progress reports and answer questions. The CRC is composed of governor-appointed representatives that reflect the spectrum of coastal interests in the state. Following a joint presentation of our project progress in April 2003, the first question from the CRC Chairman was "When can you get started on the rest of the state?" Federal and state agencies have also identified to us a number of their critical issues that we hope to address in the final stages of the project: # Inlets and Overwash: Define the probable location of future inlets and the vulnerability of each barrier segment to inlet versus overwash dynamics. What are the positive and negative values of new inlets and overwash? How should both processes be managed in the future? # Transportation Corridors: Develop an understanding of geologic processes for each barrier segment that is essential for determining the design and location of transportation corridors (e.g., Oregon Inlet bridge, Highway 12, etc.). # Shoreline Erosion: Define the short- and long-term controls and rates of erosion on ocean and estuarine shorelines. How should management respond to the loss of uplands and wetlands? # Erosion Hotspots: Determine the location of offshore sand resources suitable for beach nourishment. Can nourishment sands be stored on the barrier island adjacent to hotspots? # Sea-Level Rise: Establish the ancient and modern record of sea-level rise in NC and project future impacts upon the NC coastal system. # Habitats: Characterize the loss of critical coastal habitats such as coastal marshes, submarine shoals and aquatic vegetation, and upland maritime forests.